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16. ABSTRACT The paper summarizes material presented at ASHRAE's Indoor Air Quality (IAQ) '88 meeting, in Atlanta, Georgia, in April 1988. One conclusion drawn from several papers presented at the meeting, focussing on the role of particulate and gaseous air cleaners in improving IAQ, is that air cleaners have an important role in improving IAQ. However, they must be designed, operated, and maintained properly. There are two main classes of indoor air cleaners: in-duct and room cleaners. In-duct cleaners are installed within heating, ventilating, and air conditioning (HVAC) systems, and depend on the HVAC fans, ducts, etc. to move dirty air into the air cleaner and cleaned air back into the building. Room air cleaners are self-contained, and designed to handle the air in a single room. Particles in both types of cleaners are collected by fibrous filtration, electrostatic precipitation, or electrostatically augmented filtration. Organic vapors are usually adsorbed by activated carbon filters which can be installed in either type of cleaner. Although many comments in the paper apply to both types of cleaners, it focusses on in-duct units. The rest of the paper discusses factors that affect air cleaner effectiveness, data on particulate and organic cleaners, and measurement techniques.

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Air cleaners and indoor air quality

By Leslie E. Sparks, Ph.D.

SEVERAL papers presented at IAQ 88 focused on the role that particulate and gaseous air cleaners can play in improving indoor air quality. One conclusion that can be drawn from these papers is that air cleaners can play an important role in improving indoor air quality (IAQ). In order to do this, however, they must be designed, operated and maintained properly.

There are two main classes of indoor air cleaners: in-duct and room cleaners. In-duct cleaners are installed within the heating, ventilating and air conditioning systems. In-duct units depend on the HVAC fans, ducts, etc. to move dirty air into the air cleaner and clean air back into the building. Room air cleaners are self-contained and are designed to handle the air in a single room.

Particle collection in both in-duct and room air cleaners is achieved by either fibrous filtration, electrostatic precipitation, or electrostatically augmented filtration. Organic vapors are usually adsorbed by activated carbon filters which can be installed in either in-duct or room air cleaners.

While many of the comments in this article apply to both in-duct and room air cleaners, the discussion will focus on in-duct air units.

Air cleaner pollutant removal

Particulate air cleaners: Ensor et al. reported data on particle collection by in-duct air cleaners at IAQ 88. The method they used to determine the performance of particulate air cleaners is measurement of collection efficiency as a function of particle diameter. These measurements can be combined with data on ventilation effectiveness and modeling to determine the air cleaner effectiveness. The instrumentation used in the testing consisted of laser particle counters (LPCs) and a mobility separator (DMPS) with a condensation nucleus counter as a detector. The LPC provides data on particles with diameter from 0.09 to 3 μm. The DMPS provides data on particles with diameters from 0.011 to 0.457 μm. Ensor et al. provided data on a several filters: common furnace filters, ASHRAE 40 percent filters, ASHRAE 65 percent filters, ASHRAE 85 percent filters and ASHRAE 95 percent filters.

All of the filters were effective for collection of large particles and for very small (diameter < 05 μm) particles. And all of the filters showed a definite minimum in collection in the 0.1 to 1 μm particle diameter range. (The results are in line with theoretical expectation for filters.) The furnace filter, the ASHRAE 40 percent filter, and the ASHRAE 65 percent filter were all less than 30 percent efficient in the 0.1 to 1.0 μm diameter range. The ASHRAE 85 and 95 percent filters were over 50 percent efficient in the same diameter range.

The electrostatic air cleaner tested was about 90 percent efficient for all particle diameters.

The efficiency required to provide good indoor air quality depends on the nature of the pollutant being controlled. If the pollutant is cigarette smoke, the particle collection efficiency in the 0.1 to 1 μm diameter range is critical. If dust and lint are being controlled, then the particle collection efficiency of the larger diameter particles is important.

Electrostatic air cleaners can generate ozone, a harmful pollutant gas. The ozone generation is a function of the electrostatic air cleaner design and the power used by the air cleaner. A well designed, operated and maintained electrostatic air cleaner should not produce harmful levels of ozone.

The available data indicate that simple activated carbon filters are not likely to be effective for controlling organic vapors at the parts per billion level found in indoor environments. The data show that small activated carbon filters might be able to reduce organic vapor concentrations from short-term spills. Long-term effectiveness of carbon filters requires that the filters be regenerated on a frequent schedule.

Air cleaner effectiveness

Air cleaner effectiveness deals with the question "How much does an air cleaner improve indoor air quality?" It is a system question because the answer depends on both the air cleaner itself and on the general air cleaner installation. Air cleaner effectiveness is a function of the pollutant collection efficiency of the cleaner and of the air circulation through the cleaner. The air circulation through the cleaner is related to the general topic of ventilation effectiveness. Ineffective ventilation will negate the benefits of the most efficient air cleaner.

Air cleaner effectiveness is difficult to determine because it depends on both the air cleaner and the way it is installed. A way to study air cleaner effectiveness is to combine the work discussed above with indoor air quality models to determine the impact of air cleaners on simulated IAQ problems. A model presented at IAQ 88 was used to carry out a range of simulations on the impact of air cleaners on indoor air quality.

The results of the simulation show that for in-duct air cleaners to be effective, the air handling system must be on at all times—not a very surprising result. The simulations show that with normal air circulation rates, even low efficiency filters (30 percent or less) can improve indoor air quality. Filters with higher efficiencies, of course, improve air quality even more. It should be noted, however, that as the relative difference between a 70 percent filter and a 95 percent efficient filter is small due to the high air circulation rate normal for HVAC systems.

The simulation shows that poor ventilation effectiveness, due to short circuiting or bypassage, for example, greatly reduces the usefulness of air cleaners.

The research results presented at IAQ 88 show that air cleaners can play an important role in improving air quality. However, before air cleaners can be widely applied, considerable work on defining performance and effectiveness is necessary. Work on the impact of air cleaners on biological aerosols is especially important as is work to develop methods of evaluating air cleaners. □

About the author

Leslie E. Sparks is a chemical engineer in the Indoor Air Branch of the Environmental Protection Agency's Air and Energy Engineering Laboratory. His research interests are air cleaners, ventilation effectiveness, air movement in buildings, and indoor air quality modeling. Dr. Sparks holds a Ph.D. in air resource engineering and an M.S. degree in chemical engineering from the University of Washington. His B.S. degree is in chemical engineering from the University of Oklahoma.

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